LEAD CADMIUM AND ZINC POLLUTANTS

THIS PAPER IS WRITTEN AS A FULFILLMENT REQUIREMENT OF GEOLOGY 570 ALSO AS A PARTIAL FULFILLMENT OF THE BACHELOR OF SCIENCE DEGREE IN THE DEPARTMENT OF GEOLOGY.

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ADVISOR

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INTRODUCTION

This thesis is written to introduce the reader to three heavy metal pollutants (lead, cadmium, and zinc) which receive far too little publicity. In essence this paper is a two part project. The first involves research into the numerous aspects of these heavy metals some of which are health, the metals sources, their occurence and distribution, the principles of protection against them, and means of reducing their concentrations in the environment. The second part involves water sampling and analyses which was conducted along the Olentangy River and Alum Creek in Columbus, Ohio.

It is my sincere hope that the reader will become acquainted with these slightly known and less understood pollutants and, then armed with knowledge, the results of this water sampling will impress upon the reader that pollution by trace elements is not an uncommon occurence that can be forgotten in the pollution picture.

Although this paper is concerned essentially with zinc, cadmium, and lead, I feel it would be appropriate to briefly describe pollution in general because it includes tracemental pollutants.

"Man is but one species living in a world with numerous others. He depends on many of these others not only for his comfort and enjoyment but for his life. Plants provide mechanism for converting energy from the sun to useable energy for the rest of the earths inhabitants. They maintain the oxygen content and provide food for man and animals. Also microorganisms plants and animals are useful because (microorganisms especially) have a capacity to absorb and decompose pollutants and purify the soil, air and water. Also many species stand as ready-made systems for monitoring and warning man of dangers from pollutants. Man has found tampering with dynamic systems, in which he lives, often desirable and necessary such as in agricultrue, but often tampering produces unexpected results which may be damaging. Effects of pollution fall into the category."[1]

"The danger to environmental quality is among the most important domestic problems today. Current levels of water and air pollution, noise and congestion might be bearable to individuals is entirely pollutible that the biological effects of these environmental hazards, some of which reach man slowly and silently over decades of generations, will first begin to reveal themselves only after their impact has become irreversible."[2]

(1). Restoring the Quality of the Environment
(2). Facts on File 238 G3, 1967

Many people probably share the belief stated in the second quote concerning, "the biological effects which may reach man slowly and silently over decades of generations may first begin to reveal themselves only after their impact has become irreversible." It is my wish that upon concluding this paper the reader will perceive as I did that the heavy trace elements (lead, cadmium, and zinc) could easily be of this hidden variety of pollutant which hides it effects until they are irreversible.

HEALTH ASPECTS

It would be unwise to plunge into the subject of health aspects of heavy metal pollutants without an understanding of the medical terminology involved. The following is a listing of some of the numerous terms used when discussing heavy metal pollutants and other dangerous industrial materials.

TOXICOLOTY - The study of the action of poisons on the living organisms.[3]

TOXICITY - Ability of a chemical molecule or compound to produce injury upon reaching a susceptible site in or on the body.[3]

ACUTE - In medical sense means of short duration as applied to materials which are inhaled or absorbed through skin, it refers to a single exposure (duration seconds, minutes, or hours), as applied to ingested materials refers to single quantity or dose.[3]

CHRONIC - Means long duration, as applied to materials inhaled or absorbed through skin refers to prolonged or repeated exposures of duration measured in days months or years. Applied to injected materials refers to repeated dose over a period of days months or years. Chronic implies that exposures of doses would be relatively harmless unless extended or repeated over long periods of time (days, months, or years).[3]

LOCAL - Refers to site of action of agent and means the action takes place at the point or area of contact. Site may be skin, mucous membrane of eyes, nose, mouth, throat, or anywhere along respiratory or gastrointestinal system. Absorption does not necessarily occur.[3]

SYSTEMIC - Refers to site of action other than point of contact and presupposes that absorption has taken place. It is possible, however for toxic to be absorbed through a channel (lungs, skin, intestinal canal) and produce later man infestations on one of those channels which are not a result of the original contact. It is possible for some agents to effect a single organ or tissue as a result of both "local" and "systemic" actions.[3]

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ABSORPTION- A material is said to have been absorbed only when it has gained entry to the blood stream and consequently may be carried to all parts of the body. Absorption requires that a substance pass through the skin, a mucous membrane, or the air sacs (alveoli) of the lungs. It may also be produced by a needle (subcutaneous, intravenous etc.) but this is not important in industrial toxicology.[3]

TOXICITY RATINGS

UNKNOWN

(a) No toxicity information could be found in literature or was known by the authors
(b) Limited information based on animal experiments was available but opinion of authors this information was applicable to humans.
(c) Published toxicity reports were considered of questionable validity.

NO TOXICITY

(a) Materials which cause no harm under any conditions of use.
(b) Materials which produce toxic effects on humans only under the most unusual conditions or by overwhelming dosage.

SLIGHT TOXICITY

(a) Acute Local-Materials which on single exposure (seconds, minutes or hours) cause on slight effects to skin or nucous membranes regardless of extent of exposure.
(b) Acute systemic - Materials which can be absorbed into body by inhalation, ingestion or through the skin and which produce only slight effects following single exposures lasting (seconds, minutes, or hours) or following ingestion of a single dose, regardless of quantity absorbed or the extent of exposure.
(c) Chronic Local - Materials which on continuous or repeated exposures extending over periods of days, months, or years, cause only slight harm to the skin or mucous membranes. The extent of exposure may be great or small.
(d) Chronic Systemic - Materials which can be absorbed into the body by inhalation, ingestion or throuth

3. Dangerous Properties of Industrial Materials: Sax, Irving N TSS, 3 H353 1963

the skin and which produce only slight effects following continuous or repeated exposures extending over days months years. The extent of the exposure may be great or small.

MODERATE TOXICITY

(a) Acute Local - Materials which on single exposure lasting seconds, minutes, or hours cause moderate effects on the skin or nucus membranes. These effects may be the result of the intense exposure for a matter of seconds or moderate exposure for a matter of hours.

(b) Acute Systemic - Materials which can be absorbed into the body by inhalation, ingestion, or through the skin and which produce moderate effects following single exposures lasting (seconds, minutes, or hours) or following ingestion of a single dose.

(c) Chronic Local - Materials which on continuous or repeated exposure extending over periods of (days, months, or years) cause moderate harm to the skin or mucous membrane.

(d) Chronic Systemic - materials which can be absorbed into the body by inhalation, ingestion or through the skin and produce moderate effects following continuous or repeated exposures extending over periods of (days months or years).

SEVERE TOXICITY[3]

(a) Acute Local - Materials which on single exposures lasting seconds or minutes cause injury to skin or mucous membranes of sufficient severity to threaten life or to cause permanent physical impairement or disfigurement.

(b) Acute Systemic - Materials which can be absorbed into the body by inhalation, ingestion or through the skin and which can cause injury of sufficient severity to threaten life following a single exposure lasting (seconds, minutes, or hours) or following ingestion of a single dose.

(c) Chronic Local - Materials which on continuous or repeated exposures extending over periods of days, months, or years can cause injury to skin or mucous membranes of sufficient severity to threaten life or to cause permanent impairment, disfigurement or the irreversible changes.

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(d) Chronic Systemic - Materials which can be absorbed into the body by inhalation, ingestion or through the skin and which can cause death or serious physical impairement following continuous or repeated exposures to small amounts extending over periods of days, months, or years.

METHODS OF EXPRESSING EFFECTIVE DOSAGES [3]

THRESHOLD LIMITS - (formerly maximum allonable concetration)

(a) The threshold limit is set by the American Conference of Governmental Industrial Hygienists, and expresses conditions under which is believed that nearly all workers may be repeatedly exposed, day after day, without adverse effect. In contrast the older MAC value refers to the limiting concentrations which should never be exceeded.

MINIMUM LETHAL DOSE

(a) The amount per unit weight which will cause even one death in a group of experimental animals.

LD_{50}

(a) The amount which will kill 50% of the group of experimental animals.

HAZARD RATING [3]

(a) Term used to indicate whether a material has high, moderate, or slight toxicity or none at all.

(b) Hazard ratings are based on an interpretation of all available information, particularly Threshold Limits and LD_{50}

It is appropriate now to present a concise resume of each individual metal and its compounds properties.

Cadmium is a silver white metal with hexagonal crystals, a density of 8.642, and a melting point of 320.9C. Cadmium presents no radiation hazard but it is dangerous when heated because it emits highly toxic fumes.[3]

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Cadmium compounds are considered to have a severe toxicity rating with regard to ingestion and inhalation in acute systemic and chronic systemic cases while it has a severe toxicity rating with regard to irratant and ingestion in acute local cases. Cadmium has a variable rating when concerned with chronic local cases.[3]

Cadmium primarly affects the respiratory system upon inhalation of fumes or dust containing cadmium. Even brief exposure may result in pulmonary edema and death. Ingestion of cadmium results in a gastrointestional type of poisoning resembling food poisoning. In inhalation, symptons are usually delayed for several hours after exposure and fatal concentrations may be breathed before workmen are of sufficient discomfort to leave the contaminated ares. Ingestion results in almost immediate nausea, salvation, diarrhea and abdominal pain along with discomfort.

Lead is a blueish-gray soft metal with a density of 11.288, and a melting point of 327.43C. Lead presents no radiation hazard but emits highly toxic fumes when heated. Lead has a severe toxicity rating for ingestion and inhalation in chronic and acute systemic cases. Lead is regarded as having no toxicity in acute and chronic local cases.

Lead compounds have a severe toxicity rating for ingestion, inhalation, and absorption with regard to chronic systemic but it also has a sever toxicity rating for ingestion and inhalation in

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acute systemic cases. Lead has no toxicity rating with regard to acute and chronic local.[3]

Lead compounds are the cause of one of the oldest and commonest occupational diseases. If lead is ingested, much of it passes through the body unabsorbed and is eliminated in the feces. The greater portion that is absorbed in the body is caught by the liver and excreted, in part, by the bile. The large amounts of lead are acquired over long periods of time before lead poisoning by ingestion becomes serious. On the other hand absorption by inhalation is much more direct and thus much more dangerous. Lead is a cumaltive poison. Increasing amounts build up in the body until the point is reached where symptoms and disability occurs. Lead and lead compounds produce brittleness in the red blood cells and directly effect the organs and tissues they come in contact with, especially effected are the liver, kidneys, male gonads, nervous system, brain, and blood vessels. Symptoms of lead poisoning can be varied but in general they can include abdominal pain, constipation, diarrea, loss of appetite, nausea vomitting, lassitude, insomnia, weakness, muscle pain, irratibility, headaches, dizziness, and many others. Lead poisoning could be easily mistaken for some other minor ailment. While the true cause of lead poisoning could easily go unnoticed until the level of lead or lead compounds is dangerously high[3]

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Zinc is a white metal with hexagonal crystals, a density of 7.14 and a melting point of 419.4C. Zinc has a variable toxicity but it is generally low. Although zinc has a low toxicity rating generally except where zinc oxide fumes are emitted which can cause a sickness known as "Brass Chills".

Zinc compounds, like zinc generally, have a low toxicity rating although fatalities have occurred from high concentrations of zinc chloride fumes.

In conclusion, lead and cadmium are usually of severe toxicity compared to zinc, which usually has a low toxicity rating. Hopefully this terminology and discussion has impressed upon you that these heavy trace elements have numerous ways of expressing their symptoms and thus can be easily mistaken for abdominal cramps, nausea, or etc, while at the same time under the right conditions of frequency and concentration these heavy trace elements can be extremely deadly.

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SOURCES OF POLLUTANTS

The sources of these particular heavy metals are of two varieties, natural and man-made.

Natural sources of pollution are often overlooked in the pollution picture. This type of pollution is primarily a result of the release of heavy metals from the rocks in the soil into the ground water or as heavy metal mine-wastes. Cadmium is present in zinc oxide and other ores as an impurity, while lead and zinc are present as oxides, and sulfides in the soil

In conclusion these natural sources of pollution are little understood and studied. In the future, scientists may find that natural pollution contributes a much larger share to the heavy metal pollution than was previously thought. In any respect this problem deserves much more consideration.

Man-made sources of heavy metal pollutants are extremely variable. Because of this wide variety of sources, it is hard to pinpoint the source of the pollution, besides the fact that pollution could be partially or in whole from a natural source.

Lead and its compounds have perhaps the widest variety of sources of the three pollutants. These sources are either inorganic or organic. Some of the inorganic sources are lead paint, lead paint wastes, pottery glazing, pigment factories using lead chromate or red lead, lead arsenate in pesticides, lead mine waste water, lead chemicals used as fungicides, calcium arsenate insecticides,

and many others. Organic lead sources consist essentially of tetraethyl lead ($Pb(C_2H_5)4$), which is added to gasoline as a no knock agent. This is probably the most publicized form of lead pollution, and rightly so. For example, it has been calculated that since 1923 enough lead has been emitted by internal combustion engines to cover the Northern Hemisphere with ten milligrams of lead per sq. meter.[1]

Cadmium sources include cadmium plating effluents, plating in food cans and where ever cadmium is used in industry. Students from the University of Toronto have found almost double the heart disease in areas with soft water compared to areas with hard water. Cadmium has been suggested as the possible cause. The source is believed to be cadmium as a contaminate of zinc used to galvanize iron pipes. The belief is that soft acidic surface waters dissolved the cadmium from the zinc. It is calculated that lemonade stored in a galvanized pail can dissolve enough cadmium to cause acute cadmium poisoning to persons drinking the lemonade.[5]

Zinc sources include wastes from factories making zinc compounds, zinc plating wastes galvanizing wastes, viscose rayon wastes and waste waters from the manufacture of rubber.

(1). Restoring the Quality of the Environement
(5). Science News 95: 471 My 17, 1969

The sources of these pollutants are numerous thus making the problem of pinpointing the source of the pollutant in any specific case probably more difficult than expected. Obviously if a sample can be taken directly from a companies waste water, the problem of pinpointing the source is eleminated, but on the other hand, companies often discharge their waste water into storm sewers which are used by many other companies. Therefore it is apparent that this procedure for discharge of waste water can, under the right circumstances, compound the problems of pinpointing a pollutor, especially when numerous other companies are using the same storm sewer for their waste removal.

OCCURENCE AND DISTRIBUTION OF POLLUTANTS

Lead, cadmium and zinc occur in the air, water and soil. The distribution in terms of parts per million varies immensely according to source of the pollution (natural or man-made), raw amounts of the pollutant and its concentration, the amount of dilution, the number of organisms the pollutant has passed through before being sampled (what stage in the food chain), and other factors.

Occurrence of these trace elements in the atmosphere has been documented in reports released by the National Air Sampling Network: a division of the United States Department of Health, Education and Welfare. A large majority of the cadmium and zinc in the atmosphere can be attributed to release of suspended particles from industrial combustion, while lead in the atmosphere does originate by industrial combustion, especially coal, the majority of the lead in the air originates from combustion of leaded gasolines in internal combustion engines. In example, evidence submitted to the President's Science Advisory Committee stated that pasture grass near a major highway yielded as much as three thousand parts per million of lead, while pasture grass next to less frequent traveled highway yielded as much as seven hundred parts per million of lead. Grass ranging from fifty to one thousand feet from the highway yielded from five to fifty parts per million of lead.[1] Evidence established a method by which lead cadmium, and zinc in the atmosphere obtains entrance into the plant and animal life and possibly as far as man.

1. Restoring the Quality of the Environement.

Occurrences of lead, cadmium and zinc in fresh and salt water are well documented. These pollutants get into the water by settling of suspended particles in the atmosphere, and from natural and man-made sources, some of which were listed earlier. Most water sampling with regard for the heavy trace elements is only concerned with the metalic elements held in solution because the suspended matter in water is removed before it reaches the costumer. Although the data on the Lake Erie Basin and Ohio River basin are also concerned only with concentrations of metalic elements in solution, the concentrations of trace elements in the suspended matter of water should not be overlooked because it is possible that greater concentrations of trace elements in the suspended matter which eventually settles to the bottom where it begins to be incorporated into the food chain which could eventually reach man. It is suspected that the mercury pollution of fish in Lake Erie is due to the large concentrations of mercury in the settled matter, which becomes incorporated in fish through the food chain.

The occurrence of trace elements in the soil has gained a great deal of interest in the past ten years. Originally natural trace element pollution from the soil was thought to have little concequence, but an article by Warren, Delavault and Croos (1967) introduced new evidence. Data gathered during the periods 1960-65, allowed the authors to come to the conclusion that in many areas of Sweden, Northern Scotland, and Ireland there appears to be a relationship between soils that have abnormal amounts of copper, zinc, and lead and the districts with an abnormally high prevalence

of multiple sclerosis; likewise abnormal concentrations of zinc and lead in the soils of at least two localities are associated with an abnormally high overall mortality rate, and specifically with an above normal mortality rate for cancer of the stomach.[4] In the authors conclusion, all trace elements should be considered as possible cause of M.S. and other diseases, although more investigation is needed.

In concluding the section on occurence and distribution, the reader should analyse the information in the tables on pages 25-29, in light of the United States Public Drinking Water Standards. The drinking water standards for cadmium is one-hundreths of one part per million, for lead the standard is five-hundreths of one part per million, and the standrad for zinc is five parts per million. In view of the facts gathered and compiled in these charts, it is understandable how fish, vegetation and animals which humans consume can have a higher concentration of these heavy trace elements than permissible by the USPHS standards for drinking water.

PRINCIPLES OF PROTECTION

Principles of protection are of two kinds, medical control and engineering control, which apply essentially to workers because heavy trace elements like lead, cadmium and zinc are seldom encountered by nonworkers. Essentially the average person, unless he is an industrial worker involved with one of these metals directly, will never know whether he or his children are consuming a high concentration of one of these metals of not.

Since the worker is confronted with the health problem, management has a obligation to provide medical control which includes: (1) replacement physical examinations to insure that a new worker does not have a susceptiblity to harmful exposure, (2) periodical examinations with the purpose of detecting any poisoning in its early states, (3) education with the purpose of informing workers of any potentially harmful materials, (4) personal protective devices with the purpose of supplying protection only when engineering principles offer insurmontable difficulties, and then the protective devices should only be used for short periods of time.[3]

Engineering controls initiated to protect the worker include: (1) procedures applied to working environement such as substitution of a less toxic in place of a more toxic substance and enclosure of a process, (2) ventilation of a hazardous area, (3) wetting to limit

3. Dangerous Properties of Industrial Materials: Sax, N. Irving TSS 3 H353 1963

atmospheric dispersal of contaminants, (4) neutralization or inactivation of chemical compounds.

Principles of protection for the average person and his family who are not knowingly exposed to heavy trace elements, consists of common sense, because the most common problem is the drastic occurence when a child eats a lead based paint chips for a prolonged period of time. To insure safety people should try to find out if interior paint in their dwellings are of a poisonous nature or not.

METHODS OF REDUCING CONCENTRATIONS

Most people will never be associated with any form of pollution control in their lives, either due to apathy or inability to directly express their wish to reduce pollution due to a lack of time in which to become actively involved. So as far as the majority of people are concerned, pollution abatement rests solely in the hands of the federal and state agencies.

In curbing the effluent of pollutants into the environement, it appears that the simplest methods of control is the best, this control constitutes the action by government to stop pollution of all kinds at its source. On the other hand, the pollutors simplest and most economical method of pollution abatement is reuse and recyclying. Once this plan has been initated, more often then not, the pollutor saves money, but more importantly the expollutor is saving some of the valuable resources (natural) which may become more difficult to replace in the years to come.

Pollution is a problem which, as expressed before, may be a process which will achieve or has already achieved an irreversible effect on the environement.

EXPERIMENTATIONS

The experimentation phase of this thesis constitutes water sampling of small sections of the Olentangy River and Alum Creek, drinking water from the Columbus Greyhound Bus Depot and from my residence, 4040 N. High St.. The samples were taken on three consecutive weekends in April of 1971. The locations of sample sites are given on page 22-24.

As soon as possible after the samples were collected, they were analysed on a Perkins-Elmer Model 303 atomic absorption spectrophotometer. The results for cadmium and zinc were obtainable by the simple aspiration method, while the lead results had to be obtained by using the "sampling boat" which lowered the detection limit so that desireable results could be obtained.

Results obtained over the three week period indicated that little cadmium or zinc was present at the locations sampled, at that particular time, while some significant results were obtained concerning the lead concentrations. The results of the expermentation can be found on pages 27-29.

In several instances the lead concentrations were above the public health standard of 5 hundredths part per million. Obviously either natural pollution is the cause or some variety of man-made pollution is being released into the water which far exceeds the public health standard. In either case a serious investigation is warranted.

CONCLUSION

The most important finding of the research is that lead, cadmium, and zinc can be considered as good examples of "those environmental hazards, which reach man slowly and silently over decades of generations, and will first begin to reveal themselves only after their impact has become irreversible."

Besides concluding that these three pollutants are of a hidden nature, my experimentation showed that although cadmium and zinc concentrations from the few sites were within Public Health Service limits, the samples contained excessive concentrations of lead indicating that the water is being contaminated by lead. As previously stated lead can have a highly variable source which tends to make its discovery difficult.

In view of this finding, more investigations should be undertaken to determine the source of the contamination at these locations on the Olentangy river and Alum Creek. This investigation should continue until the sources are pinpointed and the pollution is ceased. Also the investigation should include other possible sites of pollution along the rivers of Columbus.

2. Facts on File 238 G3, 1967

SAMPLING LOCATIONS

No. I. Samples were taken from discharge pipe belonging to the Columbus Southern Ohio Electric Co. located on Spring St.

No. II. Samples were taken from another discharge pipe belonging to the Columbus and Southern Ohio Electric Co. located on Spring St.

No. III. Samples were taken from a storm sewer located between Long St. and Broad St. on the east of the Scioto River.

No. IV. Samples were taken from another storm sewer located on the east bank of the Scioto River just north of the Main Street crossing.

No. V. Samples were taken from the east bank of the Alum Creek South of Livingston Ave. near Medina Dr.

No. VI. Samples were taken from storm sewer located on the west bank of Alum Creek just south of Main St.

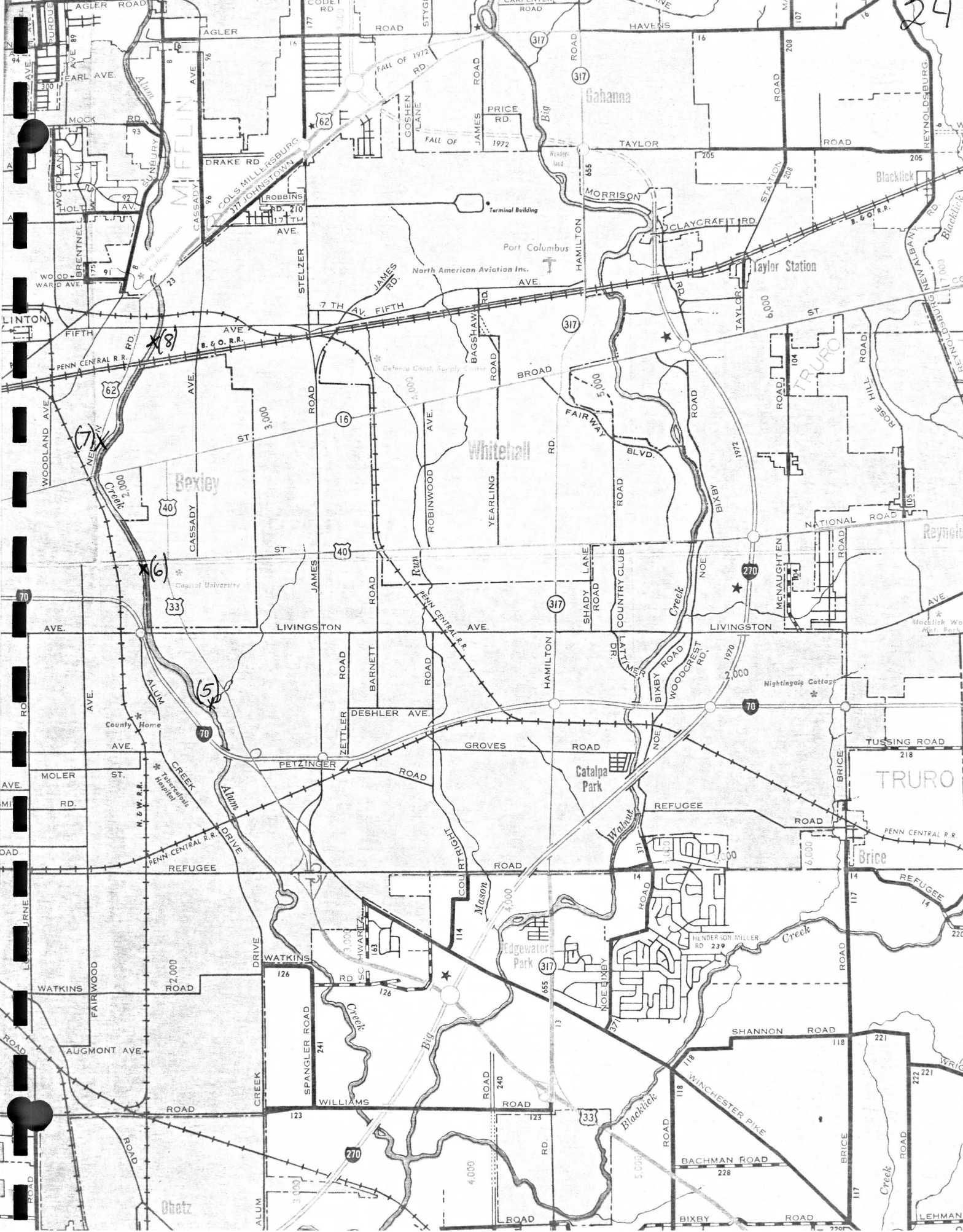
No. VII. Samples were taken directly from the edge of river in the Nielson Mills Park located just north of Clifton Ave. at Nielson Rd.

No. VIII. Samples were taken directly from the edge of the river in Hayden Park located on Hayden Park Dr. which is just south of Fifth Ave. and Neilson Rd.

No. IX. Samples were taken from the public drinking fountain at the Columbus Greyhound Bus Depot, 111 East Town St.

No. X. Samples were taken from facet at my residence at 4040 North High St. Columbus, Ohio.


Upper Arlington
Grandview Heights
Marble Cliff
Columbus
Grove City
Briggsdale
CLINTON
Ohio State University
Franklin County Veterans Memorial
City Workhouse
Children's Home
Maple Shade Picnic Grounds
Big Run
Marsh
Scioto River
Olentangy River
Scioto R.R.
PENN CENTRAL R.R.
C. & O. R.R.
N. & W. R.R.
ACKERMAN RD
DODRIDGE ST
HUDSON ST
ZOLLINGER ROAD
RIDGEVIEW ROAD
KINNEAR ROAD
CHAMBERS
FIFTH AVE
GOODALE ST
LEONARD AVE
BROAD ST
MAIN ST
TOWN ST
RICH ST
LIVINGSTON AVE
GREENLAWN AVE
STIMMEL ROAD
MOUND ST
SULLIVANT AVE
EAKIN ROAD
BRIGGS ROAD
FRANK ROAD
HART ROAD
BIG RUN ROAD
HYDE RD
HOME ROAD
DYER ROAD
GANTZ RD
STRINGTOWN ROAD
COLUMBUS ST
OBETZ RD
WILLIAMS ROAD
AUGMONT AVE
WATKINS ROAD
DERING AVE
FREBIS AVE
JENKINS AVE
MARKISON AVE
SMITH RD
MOLER ST
MARION ROAD
GROVEPORT ROAD
CORR ROAD
LOCKBOURNE
FAIRWOOD
CHAMPION AVE
PARSONS AVE
HIGH ST
WOODLAND AVE
NELSON
BRENTNELL AVE
WOODWARD AVE
PARKWOOD AVE
CLEVELAND AVE
MOCK
EARL AVE
HOLT AVE
25TH AVE
17TH AVE
11TH AVE
SUMMIT ST
PENN CENTRAL R.R.
COLUMBUS-MARYSVILLE LANE
(RIVERSIDE DRIVE)
McKINLEY
LAGUE
COLS.-MARBLE CLIFF (DUBLIN ROAD) ROAD
GRANDVIEW AVE
TWIN RIVERS DR.
HARRISON RD
HARPER RD.
VALLEY VIEW DR.
FISHER AVE
EUREKA
WHITE-THORNE
DERRER ROAD
WILSON RD
WEDGE-WOOD DR.
BRINKER AVE
BINNS BLVD
BLUEMM ROAD
S. WESTERN RD
HARMON RD
EMG RD
BROWN ROAD
GANTZ ROAD
McCOMB ROAD
BIG RUN AVE
WESTERN RD (JACKSON PIKE)
OPEN
FOURTH ST
THIRD ST
LONG ST
SPRING ST
FULTON ST
TREMONT BLVD
N.W. BLVD
MOUNTVIEW
REDDING ROAD
LANE AVE
NORTH STAR ROAD
OLENTANGY RIVER ROAD
X(1)
X(2)
X(3)
X(4)
X(9)


AGLER ROAD
AGLER ROAD
EARL AVE.
MOCK RD.
DRAKE RD
COLS MILLERSBURG
317 JOHNSTOWN
ROBBINS RD.
17TH AVE.
HOLT AVE.
WOODLAND AVE.
BRENTNELL AVE.
WOODWARD AVE.
MIFFLIN
SUNBURY
CASSADY AVE.
STELZER
FALL OF 1972 RD.
GOSHEN LANE
JAMES ROAD
PRICE RD.
Gahanna
TAYLOR ROAD
REYNOLDSBURG
Big Walnut Creek
Wunderland
MORRISON
Terminal Building
CLAYCRAFT RD.
B. & O. R.R.
Blacklick
STATION
Port Columbus
North American Aviation Inc.
HAMILTON
Taylor Station
NEW ALBANY
JAMES RD.
7TH AV. FIFTH AVE.
FIFTH AVE.
PENN CENTRAL R.R.
BAGSHAW RD.
BROAD ST.
6,000
TRURO
ROSE HILL ROAD
Defense Const. Supply Center
Whitehall
FAIRWAY BLVD.
ROBINWOOD AVE.
YEARLING RD.
BIXBY ROAD
1972
Bexley
CREEK
NELSON
WOODLAND AVE.
CASSADY AVE.
ST. 3,000
ROAD
NATIONAL ROAD
Reynoldsburg
Capital University
JAMES ROAD
Run
PENN CENTRAL R.R.
SHADY LANE
COUNTRY CLUB
NOE
McNAUGHTEN ROAD
LIVINGSTON AVE.
LIVINGSTON AVE.
ALUM CREEK
BARNETT ROAD
HAMILTON
LATTIMER
BIXBY ROAD
WOODCREST RD.
1970
2,000
Nightingale Cottage
DESHLER AVE.
ZETTLER ROAD
County Home
GROVES ROAD
TUSSING ROAD
PETZINGER ROAD
Catalpa Park
TRURO
MOLER ST.
Tuberculosis Hospital
N. & W. R.R.
CREEK
Alum
REFUGEE ROAD
Walnut
PENN CENTRAL R.R.
Brice
DRIVE
COURTRIGHT ROAD
Mason
Edgewater Park
HENDERSON RD.
Creek
WATKINS ROAD
SCHWARTZ RD.
SHANNON ROAD
FAIRWOOD
SPANGLER ROAD
AUGMONT AVE.
WILLIAMS ROAD
WINCHESTER PIKE
BACHMAN ROAD
Blacklick
BRICE
Obetz
BIXBY ROAD
LEHMAN
(1) (2) (3) (4) (5) (6) (7) (8)

USUAL RANGE OF COPPER, ZINC, AND LEAD IN ROCKS, SOILS, AND PLANTS

All amounts in Parts per million:

	CU	ZN	PB
Rock. (Awau-regia-extractable metal)	1-10	25-75	1-5
Soil.(Sulphuric-acid-extractable metal)	5-70-	35-300	2-10
Plants(Other than food, content in ash)	100-300	500-3000	10-75
Plants (edible portion, content in ash)	30-200	70-600	2-20

(5)

Positive sites-areas showing evidence of unusual prevalence of Multiple Sclerosis.

Negitive sites-ares showing no evidence of unsual prevalence of Multiple Sclerosis.

THE AVERAGE COPPER, ZINC LEAD, AND ORGANIC CONTENT OF SOME SETS OF SOIL SAMPLES FROM "POSITIVE" AND "NEGATIVE" AREAS

"Positive" Sites"				
Locality	Cu	Zn	Pb	%of organic
Shetland Ils.	33	125	61	more than 16.7
Orkneys Ils.	7	84	30	8.3
Northern Ireland	17	116	14	18.1
C---Gloucestershire	44	433	294	4.7
C---District "	36	171	134	6.6
L---Farm Somerset	14	216	158	7.4
Baslow, Derbyshire	31	228	406	7.0
R--G---Northumberland	39	268	125	11.5
H---Town Northumberland	21	234	152	6.9
S---Farm Northumberland	2	31	46	4.5
Berre Alston, Devonshire	143	947	627	8.4
"NEGITIVE"SITES				
Amberley, Sussex, England	6	104	13	4.1
Elsted, Sussex, England	3	78	9	7.0
Coldhayes Hants	2	42	7	6.4
Nyewood Sussex, England	5	52	11	3.1
Saskatchewan, Canada	8	54	4	8.2
Manitoba	11	56	4	---
Ontario	8	53	4	5.5
Prince Edward Iis. Canada	2	30	9	---

(5)

SUMMARY OF TRACE ELEMENTS IN WATERS OF UNITED STATES mg/l

	Occurences	Freq. of detection	min	max.	mean
Lead	305	19.5%	.002	.140	.023
Cadmium	40	2.5%	.001	.120	.095
Zinc	1207	76.5%	.002	1.183	.064

(6)

HIGHEST RECORDED TRACE METAL CONCENTRATIONS BY BASIN

Zinc - 1.182 mg/l in lake Erie basin, Cuyahoga River at Cleveland, Oh.

Cadmium-.120 mg/l in Lake Erie Basin, Cuyahoga River at Cleveland, Oh.

Lead - .140 mg/l Ohio River Basin, Ohio River near Evansville, Ind. (6)

SUMMARY OF TRACE ELEMENTS - OHIO BASIN mg/l

	Occurences	Freq. of detection	min.	max.	mean
Zinc	198	81.8%	.003	.787	.081
Lead	45	18.6%	.010	.140	.030
Cadmium	7	2.9%	.002	.011	.007

(6)

SUMMARY OF TRACE ELEMENTS - LAKE ERIE BASIN mg/l

	Occurences	Freq. of detection	min.	max.	mean
Zinc	41	87.3%	.010	1.183	.205
Lead	13	27.7%	.016	.090	.039
Cadmium	4	8.5%	.006	.120	.050

(6)

6. Trace Metals in Waters of the United States, Kopp, John E. and Kroner, Robert C.

WATER SAMPLE RESULTS

No. (samples taken 4/18/71)	Pb.	Cd.	Zn. (PPM)s.
No. I	.014	.01	.020
No. II	.009	.01	.045
NO. III	.016	.01	.012
No. IV.	.0485	.01	.1420
No. V.	.119	.01	.0275
No. VI.	.0124	.01	.0250
No. VII.	.0424	.01	.0220
No. VIII.	.019	.01	.0320
No. IX.	.0023	.01	.0070
No. X.	.0093	.01	.0070

United States Public Health Service Drinking Water Standards:

Zinc - 5.0 PPM

Lead - .05 PPM

Cadmium - .01 PPM

WATER SAMPLE RESULTS

No. (samples taken 4/24/71)	Pb	Cd	Zn	(PPM)s
No. I	.0068	.01	.074	
No. II	.001	.01	.044	
No. III	.0120	.01	.010	
No. IV	.0675	.01	.054	
No. V.	.122	.01	.010	
No. VI	.0157	.01	.010	
No. VII	.0079	.01	.010	
No. VIII	.001	.01	.020	
No. IX	.0024	.01	.010	
No. X	.0058	.01	.010	

United States Public Health Service Drinking Water Standards:

Zinc - 5.0 PPM

Lead - .05 PPM

Cadmium - .01 PPM

WATER SAMPLE RESULTS

No. (samples taken 5/3/71)	Pb	Cd	Zn	(PPM)s
No. I	.0534	.01	.039	
No. II	.0233	.02	.026	
No. III	.0148	.01	.022	
No. IV	.0289	.01	.041	
No. V	.1152	.01	.040	
No. VI	.1510	.01	.017	
No. Vii	.0775	.01	.016	
No. VIII	.0694	.01	.017	
No. IX	.0023	.01	.013	
No. X	.0302	.01	.010	

United States Public Health Service Drinking Water Standards:

Zinc - 5.0 PPM

Lead - .05 PPM

Cadmium - .01 PPM

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